PATENT ABSTRACTS OF JAPAN

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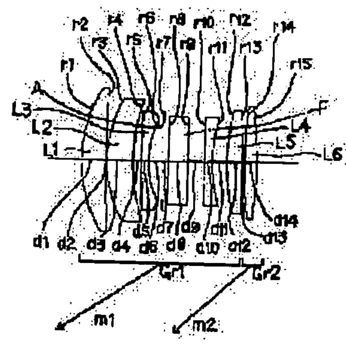
(54) PHOTOGRAPHING LENS SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a practical photographing lens system whose focus deviating image is improved over the wide range of photographing distances from infinity to the closest range.
SOLUTION: This lens system is composed, in order from the object side, of a first group Gr1; composed of a first positive meniscus lens L1 whose convex surface confronts the object side, a second positive meniscus lens L2 whose convex surface con-fronts the object side, a third negative meniscus lens L3 whose convex surface confronts the object side, a diaphragm A, an apodization filter F, a fourth lens L4 of biconcave shape and a fifth lens L5 of biconvex shape; and a second group Gr2 composed of a sixth lens L6 of biconvex shape. m1, m2 typically represent the movement of the first group and the second group at the time of focusing from a focusing state at infinity to a focusing state at the closest photographing distance. The photographing lens system performs aberration correction at a close distance by moving the whole system while widening an interval d13 between the first group Gr1 and the second group Gr2 at the time of focusing from the focusing state at infinity to the focusing state at the close range.



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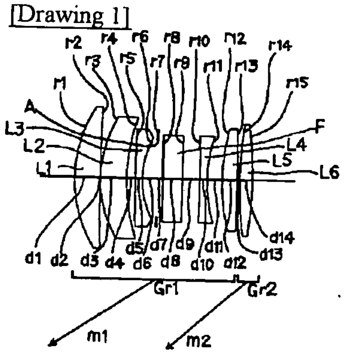
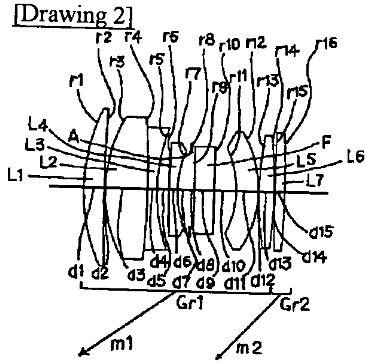
DRAWINGS

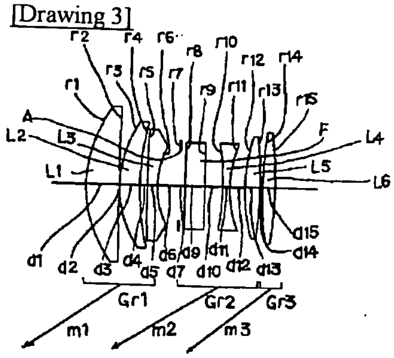
[Drawing 1]



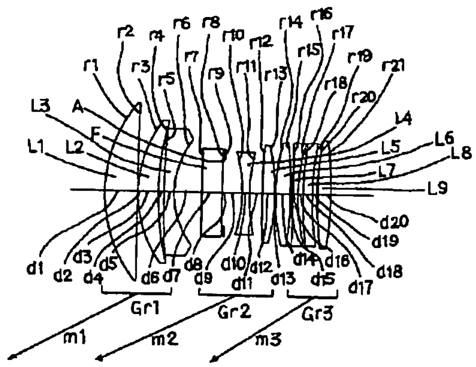
[Drawing 2]



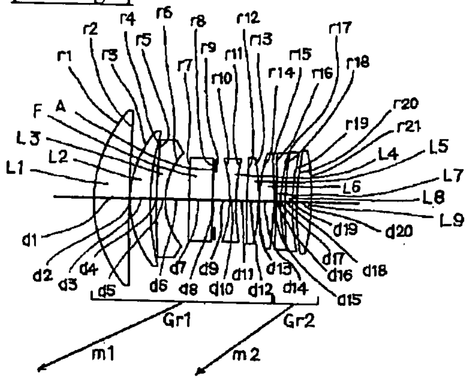
[Drawing 3]



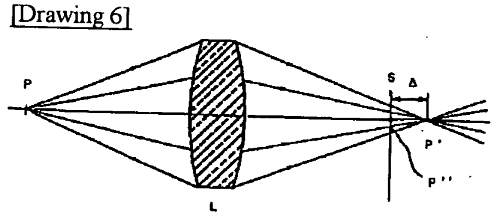
[Drawing 4]



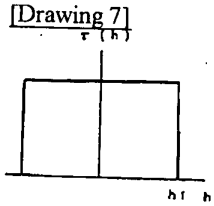
[Drawing 5]



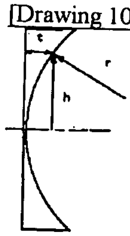
[Drawing 6]



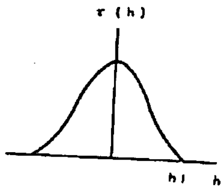
[Drawing 7]



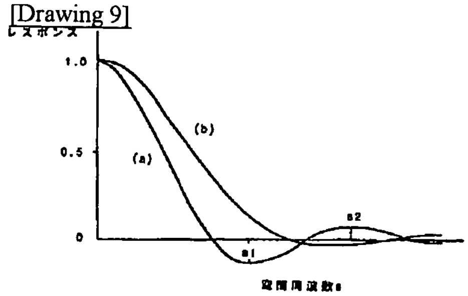
[Drawing 10]



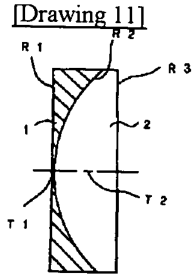
[Drawing 8]



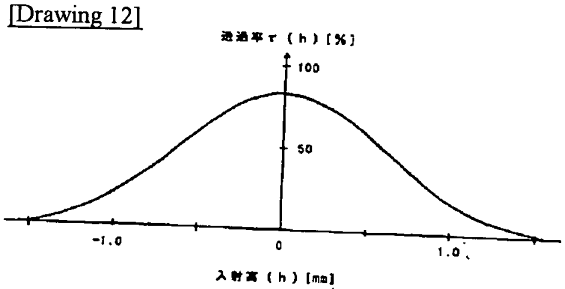
[Drawing 9]



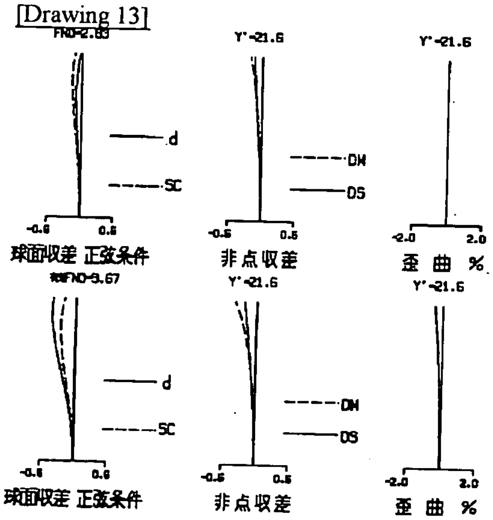
[Drawing 11]



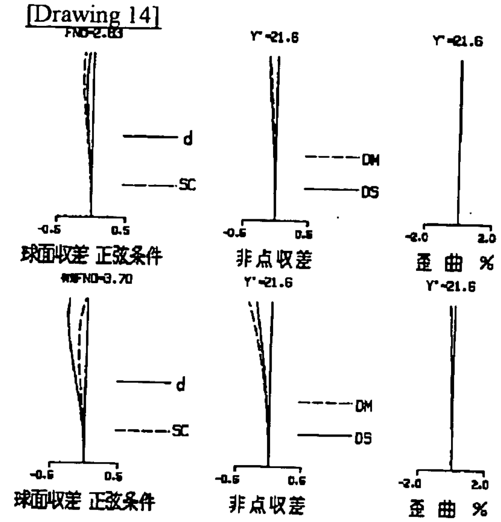
[Drawing 12]



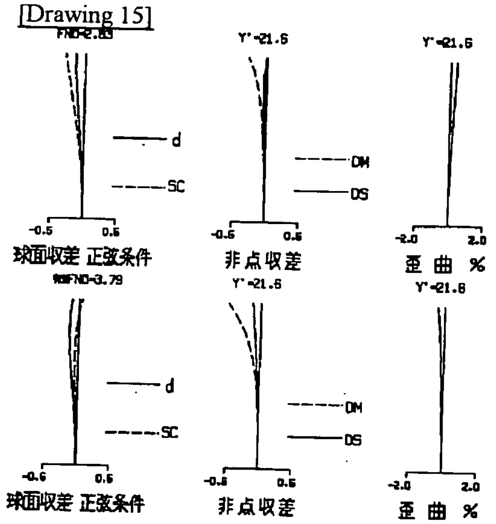
[Drawing 13]



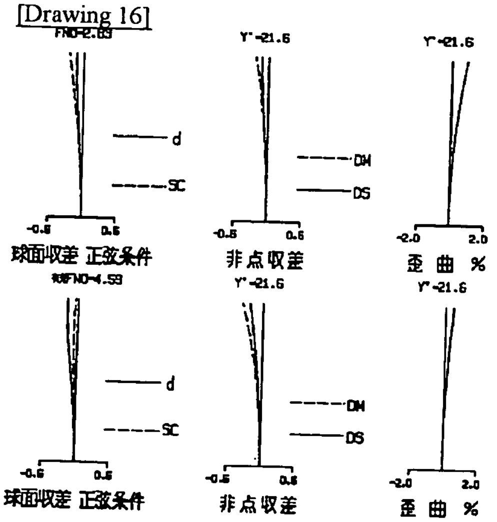
[Drawing 14]



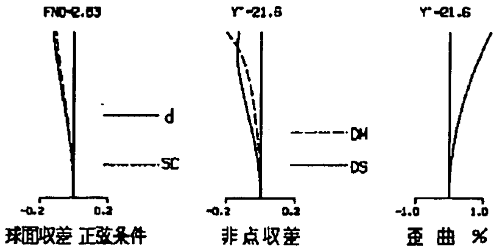
[Drawing 15]

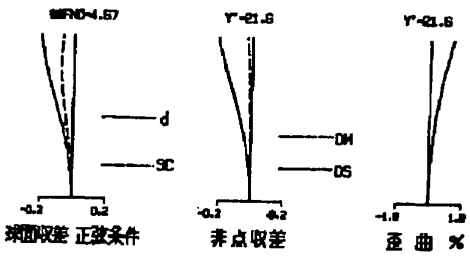


[Drawing 16]



[Drawing 17]





[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The lens plot plan of the infinite distance focus state of the taking-lens system of an example 1
[Drawing 2] The lens plot plan of the infinite distance focus state of the taking-lens system of an example 2
[Drawing 3] The lens plot plan of the infinite distance focus state of the taking-lens system of an example 3
[Drawing 4] The lens plot plan of the infinite distance focus state of the taking-lens system of an example 4
[Drawing 5] The lens plot plan of the infinite distance focus state of the taking-lens system of an example 5
[Drawing 6] The ** type view explaining improvement of an out-of-focus image
[Drawing 7] The graph showing a permeability distribution of the usual optical system
[Drawing 8] The graph showing a permeability distribution of apodization optical system
[Drawing 9] The graph of the response function of the usual optical system and apodization optical system
[Drawing 10] The cross section explaining the composition of an apodization filter
[Drawing 11] The cross section showing an example of an apodization filter
[Drawing 12] The graph which shows an example for the permeability of an apodization filter
[Drawing 13] The aberration view of the taking-lens system of an example 1
[Drawing 14] The aberration view of the taking-lens system of an example 2
[Drawing 15] The aberration view of the taking-lens system of an example 3
[Drawing 16] The aberration view of the taking-lens system of an example 4
[Drawing 17] The aberration view of the taking-lens system of an example 5
[Description of Notations]
Gr1: The 1st group
Gr2: The 2nd group
Gr3: The 3rd group
A: Drawing
F: Apodization filter

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to a taking-lens system and the taking-lens system which has a still more detailed contiguity distance aberration amendment (so-called floating) mechanism suitable as a taking lens of a camera.
[0002]
[Description of the Prior Art] Generally, the performance of a taking-lens system is estimated by the image formation performance in a focal plane. For this reason, conventionally by the taking-lens system, much proposals are performed about the amendment of many aberration that an image formation performance should be raised.
[0003] However, in the case of the taking-lens system used as a taking lens of a camera, not only an image formation performance but how an out-of-focus image appears is very important. For example, with the portrait photograph which allotted the person to the center of a picture, or the photograph of a flower by which contiguity photography was carried out, the impression of a photograph will be greatly influenced depending on how the out-of-focus image of the portion used as backgrounds other than main photographic subjects appears.
[0004] It is carried out, -- it is good, such as the state [fading softly, such as the showing-in the 3rd whole although various states, such as the state of fading softly to the whole, were known as how such an out-of-focus image appears, leaving the heart of the state (called 2 line dotage) of fading as if there were a state where the hair fades broadly like the ear of Japanese pampas grass, and the one hairs, and the hair when the hair in a portrait photograph be made into an example for example,
[0005] When a photography scale factor photos a contiguity photographic subject especially using the macro lens which are about 1 / four to 1/2, since backgrounds other than main photographic subjects serve as an out-of-focus image in almost all cases, especially how an out-of-focus image appears is important.
[0006] The lens system which has arranged the filter (apodization filter) constituted so that the amount of transmitted lights might decrease gradually as it separates in the direction perpendicular to an optical-axis center to an optical axis as a lens system aiming at improvement of an out-of-focus image is proposed by U.S. JP,3,843,235,B, it gets down to it, and the example of the lens system of the triplet composition which consists of a biconvex lens, a biconcave lens, drawing, an apodization filter, and a biconvex lens is indicated sequentially from the body side. According to the lens system indicated by this official report, the intensity distribution of an out-of-focus image are changed with an apodization filter (such an effect is hereafter called apodization), and it is supposed that an out-of-focus image is improved.
[0007]
[Problem(s) to be Solved by the Invention] However, the lens system indicated by the above-mentioned official report is not proposed about movement of the lens group in the case of focusing in the composition which has an apodization filter, although the effect of improvement of the out-of-focus image of an infinite distance focus state is proposed.
[0008] In view of the above-mentioned technical problem, photography distance crosses this invention to the latus range from infinite distance to contiguity, and it aims at offering the taking-lens system by which the out-of-focus image was improved.
[0009]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, a taking-lens system according to claim 1 Drawing arranged at two or more lens groups or two or more aforementioned lens groups, It is the taking-lens system which has the apodization filter arranged near [drawing] the above, and it is characterized by moving the whole system to a body side, changing at least one lens group interval from an infinite distance focus state on the occasion of focusing to a contiguity photography distance focus state.
[0010] A taking-lens system according to claim 2 sequentially from a body side Moreover, the 1st group, Are the taking-lens system equipped with the 2nd group and the apodization filter arranged near drawing and this drawing in the shell at the 1st group of the above, and focusing from an infinite distance focus state to a contiguity photography distance focus state is faced. It is characterized by moving the whole system to a body side, extending the interval of the 1st group of the above, and the 2nd group of the above.
[0011] A taking-lens system according to claim 3 sequentially from a body side Moreover, the 1st group, With the 2nd group and the 3rd group, in a shell in either the 1st group of the above, or the 2nd group of the above Are the taking-lens system equipped with the apodization filter arranged near drawing and this drawing, and focusing from an infinite distance focus state to a

contiguity photography distance focus state is faced. It is characterized by moving the whole system to a body side, narrowing the interval of the 1st group of the above, and the 2nd group of the above, and extending the interval of the 2nd group of the above, and the 3rd group of the above.

[0012]

[Embodiments of the Invention] Hereafter, the taking-lens system which carried out this invention is explained, referring to a drawing.

[Lens arrangement of taking-lens system of operation gestalt] drawing 1 - drawing 5 correspond to the lens block diagram of the taking-lens system of the 1-5th operation gestalten, and show lens arrangement in the infinite distance focus state. Each taking-lens system of the 1st - the 5th operation gestalt is a taking-lens system which performs short-distance aberration amendment which moves the whole system to a body side, and the so-called floating, changing at least one lens group interval, in case the apodization filter later mentioned in a lens group is arranged and focusing is carried out from an infinite distance focus state to a contiguity photography distance focus state. The arrows m1-m3 shown in drawing 1 - drawing 5 show typically the situation of movement of each lens group at the time of carrying out focusing from the infinite distance focus state of illustration to the maximum contiguity photography distance focus state.

[0013] The 1st lens L1 of the right meniscus configuration where the taking-lens system of the 1st operation gestalt turned the convex to the body side sequentially from the body side, the 2nd lens L2 of the right meniscus configuration where the convex was turned to the body side, the 3rd lens L3 of the negative meniscus configuration where the convex was turned to the body side, drawing A, Shell composition is carried out with the 1st group Gr1 which consists of the apodization filter F mentioned later, the both concave-like 4th lens L4, and the 5th lens L5 of both the convex configuration, and the 2nd group Gr2 which consists of the 6th lens L6 of both the convex configuration. The taking-lens system of the 1st operation gestalt moves the whole system to a body side, extending the interval (it corresponding to the axial upper surface interval d13 in drawing 1) of the 1st group Gr1 and the 2nd group Gr2, in case focusing is carried out from an infinite distance focus state to a contiguity photography distance focus state, and is performing the short-distance aberration amendment.

[0014] The taking-lens system of the 2nd operation gestalt sequentially from a body side The 1st lens L1 of the right meniscus configuration where the convex was turned to the body side, the 2nd lens L2 of both the convex configuration, the 3rd lens L3 that comes to join the body side by the shape of both concaves the image side of the 2nd lens L2, the 4th lens L4 of the negative meniscus configuration where the convex was turned to the body side, drawing A, Shell composition is carried out with the 1st group Gr1 which consists of the 5th lens L5 of the negative meniscus configuration where the concave surface was turned to the apodization filter [which is mentioned later] F and body side, and the 6th lens L6 of both the convex configuration, and the 2nd group Gr2 which consists of the 7th lens L7 of both the convex configuration. The taking-lens system of the 2nd operation gestalt moves the whole system to a body side, extending the interval (it corresponding to the axial upper surface interval d14 in drawing 2) of the 1st group Gr1 and the 2nd group Gr2, in case focusing is carried out from an infinite distance focus state to a contiguity photography distance focus state, and is performing the short-distance aberration amendment.

[0015] The 1st group Gr1 which the taking-lens system of the 3rd operation gestalt becomes from the 1st lens L1 of the right meniscus configuration where the convex was turned to the body side, the 2nd lens L2 of the right meniscus configuration where the convex was turned to the body side, and the 3rd lens L3 of the negative meniscus configuration where the convex was turned to the body side, sequentially from a body side, and drawing A, Shell composition is carried out with the 2nd group Gr2 which consists of the apodization filter F mentioned later, the both concave-like 4th lens L4, and the 5th lens L5 of both the convex configuration, and the 3rd group Gr3 which consists of the 6th lens L6 of both the convex configuration. When carrying out focusing of the taking-lens system of the 3rd operation gestalt from an infinite distance focus state to a contiguity photography distance focus state, The interval (in drawing 3 , it corresponds to the axial upper surface interval d6) of the 1st group Gr1 and the 2nd group Gr2 is narrowed, and the whole system is moved to a body side, extending the interval (it corresponding to the axial upper surface interval d13 in drawing 3) of the 2nd group Gr2 and the 3rd group Gr3, and the short-distance aberration amendment is performed.

[0016] The 1st group Gr1 which the taking-lens system of the 4th operation gestalt becomes from the 1st lens L1 of the right meniscus configuration where the convex was turned to the body side, the 2nd lens L2 of the right meniscus configuration where the convex was turned to the body side, and the 3rd lens L3 of the negative meniscus configuration where the convex was turned to the body side, sequentially from a body side, and drawing A, The 2nd group Gr2 which consists of the apodization filter F mentioned later, the both concave-like 4th lens L4, the 5th lens L5 of both the convex configuration, and the 6th lens L6 of both the convex configuration, Shell composition is carried out with the 3rd group Gr3 which consists of the both concave-like 7th lens L7, an octavus lens L8 of the negative meniscus configuration where the convex was turned to the body side, and the 9th lens L9 of both the convex configuration. When carrying out focusing of the taking-lens system of the 4th operation gestalt from an infinite distance focus state to a contiguity photography distance focus state, The interval (in drawing 4 , it corresponds to the axial upper surface interval d6) of the 1st group Gr1 and the 2nd group Gr2 is narrowed, and the whole system is moved to a body side, extending the interval (it corresponding to the axial upper surface interval d15 in drawing 4) of the 2nd group Gr2 and the 3rd group Gr3, and the short-distance aberration amendment is performed.

[0017] The 1st lens L1 of the right meniscus configuration where the taking-lens system of the 5th operation gestalt turned the convex to the body side sequentially from the body side, the 2nd lens L2 of the right meniscus configuration where the convex was turned to the body side, the 3rd lens L3 of the negative meniscus configuration where the convex was turned to the body side, drawing A, The 1st group Gr1 which consists of the apodization filter F mentioned later, the both concave-like 4th lens L4, the

5th lens L5 of both the convex configuration, and the 6th lens L6 of both the convex configuration, Shell composition is carried out with the 2nd group Gr2 which consists of the both concave-like 7th lens L7, an octavus lens L8 of the negative meniscus configuration where the convex was turned to the body side, and the 9th lens L9 of both the convex configuration. The taking-lens system of the 5th operation gestalt moves the whole system to a body side, extending the interval (it corresponding to the axial upper surface interval d15 in drawing 5) of the 1st group Gr1 and the 2nd group Gr2, in case focusing is carried out from an infinite distance focus state to a contiguity photography distance focus state, and is performing the short-distance aberration amendment.

[0018] Each of each above-mentioned operation gestalten arranges the apodization filter in a taking-lens system. In addition, the apodization filter is illustrated as a plate of one sheet in each drawing. About the detailed composition of this apodization filter, it mentions later.

[0019] There is an inclination for the incidence quantity of the shaft top flux of light which carries out incidence to the positive lens group by the side of an image to become high, and for spherical aberration to become an undershirt from drawing greatly in the state of the image formation to a contiguity photographic subject. Moreover, an axial outdoor daylight bunch generates the comatic aberration of the method nature of outside in order to pass through the low position near the optical axis of each lens group rather than the case of an infinite distance focus state.

[0020] It is necessary to rectify the suitable axial upper surface interval for an amendment sake for many aberration peculiar to the image formation state to these contiguity photographic subjects, to perform floating, and to suppress change of the aberration generated in contiguity photography distance.

[0021] By the taking-lens system of the above 1st, the 2nd, and 5th operation gestalten In the taking-lens system equipped with the 1st group, the 2nd group, and the apodization filter arranged near drawing and this drawing in the shell at the 1st group of the above sequentially from the body side On the occasion of focusing from an infinite distance focus state to a contiguity photography distance focus state, the floating mechanism which extends the interval of the 1st group of the above and the 2nd group of the above is adopted.

[0022] the aberration generated in contiguity photography distance also in the taking-lens system which has an apodization filter by adopting such a floating mechanism -- good -- an amendment -- things can be made, the latus range of an infinite distance focus state to a contiguity photography distance focus state can be covered, and the practical taking-lens system by which the out-of-focus image was improved can be realized

[0023] moreover, by the taking-lens system of the above 3rd and the 4th operation gestalt In the taking-lens system equipped with the apodization filter of the 2nd group most arranged near drawing and this drawing at the body side in the 1st group, the 2nd group, the 3rd group, and the shell sequentially from the body side On the occasion of focusing from an infinite distance focus state to a contiguity photography distance focus state, the interval of the 1st group of the above and the 2nd group of the above was narrowed, and the floating mechanism which extends the interval of the 2nd group of the above and the 3rd group of the above is adopted.

[0024] the aberration generated in contiguity photography distance like the case of each previous operation gestalt by adopting such a floating mechanism also in the taking-lens system which has an apodization filter -- good -- an amendment -- things can be made, the latus range of an infinite distance focus state to a contiguity photography distance focus state can be covered, and the taking-lens system by which the out-of-focus image was improved can be realized

[0025] since [moreover,] the taking-lens systems of these the 3rd and 4th operation gestalten are 3 group composition -- up to a scale factor higher than the taking-lens system of the 1st of 2 group composition, the 2nd, and 5th operation gestalten -- short-distance aberration -- an amendment -- things are made Therefore, it can be used also in the field where a photography scale factor is larger than the case of 2 group composition.

[0026] In addition, although the 3rd and 4th operation gestalten are operation gestalten which have arranged each apodization filter in the 2nd group, even if they arrange an apodization filter in the 1st group, they can acquire the same effect.

[0027] [The principle of the out-of-focus image improvement method], next the principle of out-of-focus image improvement are explained with reference to a drawing. Drawing 6 is a ** type view for explaining an out-of-focus image. In drawing 6 , lens system L of the non-aberration in which P has the point light source and L has circular opening symmetrical with an optical axis is shown. The point light source P forms **** P' by the conjugate focal plane by lens system L. Moreover, out-of-focus image P" which separated only delta from the focal plane in the direction of an optical axis and which has a size in respect of S is formed.

[0028] in addition, the thing which, as for the image formation relation in the case of actual photography, the distance of the point light source P and lens system L changes -- **** P' on the image surface -- the out-of-focus image P -- suppose that it argues about 'out-of-focus image P' [in / the parallel field S / to the focal plane which fixes the position on the optical axis of the point light source P in the following explanation since it is easy, and contains **** P' although it becomes ']'

[0029] When the permeability distribution of opening of lens system L is fixed (i.e., as shown in drawing 7 , when permeability tau (h) is constant value in the range from the optical axis to the effective radius h1 of opening), image P" of the point light source P on the image surface S becomes circle of confusion with uniform intensity.

[0030] On the other hand, permeability tau (h) decreases as it separates from an optical-axis center as shown in opening of lens system L at drawing 8 in the direction perpendicular to an optical axis, and when absorption which is set to 0 by the effective radius h1 is given, image P" of the point light source P on the image surface S becomes the circular image with which intensity distribution are similar to a permeability distribution. That is, when permeability tau (h) has a distribution like drawing 8 , out-of-focus image P" of the point light source P becomes the image with which intensity decreased as it is bright in the center

near the optical axis and it goes on the outskirts.

[0031] Since ordinary photographic subjects are considered to be the aggregates of the point light source from which brightness differs, it will fade softly, the out-of-focus image of a lens system with which permeability [of opening] tau (h) has a distribution like drawing 8 leaving the heart to a center, and can obtain a good out-of-focus image. The above is the principle of improvement of the out-of-focus image by apodization.

[0032] It is mentioned that the effect over the out-of-focus image does not ask the position of Field S, the amount of defocusing, the dotage after front dotage, etc. as a feature of apodization. That is, even if Field S is located in which position so that clearly also from drawing 6 , out-of-focus image P" of the point light source P becomes the image with which intensity decreased as it is bright in the center near the optical axis and it goes on the outskirts, as long as the effective diameter of lens system L is penetrated.

[0033] Furthermore, improvement of the out-of-focus image by apodization is explained using a response function. Drawing 9 is a graph which shows the response function of the out-of-focus image in the field which separated only delta from the focal plane in (b), when it has permeability tau (h) to which it decreases as it separates from an optical-axis center which is expressed in the following formulas (B) as (a) in the direction perpendicular to an optical axis, when opening of a lens system has fixed permeability tau (h) which is expressed with the following formulas (A).

tau(h) =1 ..... (A)

tau(h) =1-h2 ..... (B)

Moreover, in the graph of drawing 9 , a response expresses the response value normalized so that spatial frequency s might be served as by the horizontal axis and a vertical axis might be served as to 1 by spatial frequency s= 0.

[0034] A response function is also called OTF (optical transfer function), and shows the frequency transfer characteristics between a photographic subject's spectrum and the spectrum of an image. After calculating the wave aberration in a pupil depended out-of-focus and asking for a pupil function, the response function of an out-of-focus image asks for **** intensity distribution from this pupil function, and is drawn by carrying out the Fourier transform of these **** intensity distribution further.

[0035] After a response function in case the permeability of opening of a lens system is a fixed value decreases rapidly in the low-frequency component of spatial frequency, it takes a negative value once by about one spatial-frequency s=s, and shows the property (a) which serves as a value positive by about two spatial-frequency s=s further, so that the graph of drawing 9 may also show.

[0036] In the low-frequency component of spatial frequency, monotonous reduction of the response function in the case of on the other hand, decreasing as the permeability of opening of a lens system separates from an optical-axis center in the direction perpendicular to an optical axis is carried out gently, and after taking a slightly negative value by about two spatial-frequency s=s, the property (b) which serves as a positive value again is shown.

[0037] Generally, the low-frequency component of spatial frequency forms the outline composition of an image, and a high frequency component has the operation which corrects the outline composition of the image formed of the low-frequency component. Moreover, the state where a response function takes a negative value is called spurious resolution, and is equivalent to the state where the phenomenon of negative positive reversal in which a black portion becomes white and a white portion becomes black has occurred, by the actual picture.

[0038] It is thought that the picture based on the property of (a) that permeability is fixed has the large reduction in a low-frequency component, and the outline composition of an image is seldom reproduced. Moreover, the spatial-frequency ranges which will be in the state of spurious resolution since the range used as an about one spatial-frequency s=s negative value is large are latus. Furthermore, it can be said that the very unnatural image is formed from vibration of the response function in a high frequency component being remarkable.

[0039] The picture based on the property of (b) that on the other hand permeability decreases as it separates from an optical axis has the small reduction in a low-frequency component, and the outline composition of an image is reproduced more. Moreover, the range of spurious resolution is also small and vibration of the response function in a high frequency component is also small.

[0040] As mentioned above, in the case of the lens system which has opening to which permeability decreases, rather than the lens system of fixed opening of permeability, the skeleton of the picture in an out-of-focus image has clarified, and it can be said that it is fading automatically as it separates from an optical-axis center in the direction perpendicular to an optical axis. If it puts in another way, it can be said that the out-of-focus image of a lens system with which a response function has the property of (b) is in the state where it is fading softly, leaving the heart to a center.

[0041] Thus, it turns out that the out-of-focus image is improved by apodization also from the field of a response function.

[0042] A [apodization filter], next an apodization filter are explained. the 1- mentioned above -- the apodization filter currently used with the 5th operation gestalt is manufactured using the matter (ND glass) which has an optical absorption

[0043] If the influence by surface reflection of a lens is generally disregarded when the flux of light penetrates a lens, the transmitted light intensity I is expressed with the following formulas (C).

I=I0, exp (-alphat) ..... (C)

however, I0:incident-light intensity, alpha:absorption coefficient, and the thickness of t:lens -- it comes out

[0044] In the above-mentioned formula (C), since an absorption coefficient alpha is a constant determined by the lens medium, the transmitted light intensity I to the incident light of fixed intensity will be determined by only the thickness of a lens.

[0045] Using this property, the lens which has absorption to which permeability decreases can be manufactured as it separates

from an optical-axis center in the direction perpendicular to an optical axis. That is, since thickness will increase as the lens separates from an optical-axis center in the direction perpendicular to an optical axis if an absorption coefficient alpha manufactures a common concave-like lens using a big lens material as shown in drawing 10 , it becomes the lens which has absorption toward the circumference from the center of a lens.

[0046] Hereafter, a permeability distribution of such a common concave-like lens is shown. In drawing 10 , t, then thickness t are expressed [radius of curvature / of the concave surface of a lens] with the following formulas (D) by geometric calculation in the thickness of the lens in height h from r and an optical axis.

t=r-root (r2-h2) ..... (D)

In the above-mentioned formula, if a binominal expression is carried out noting that h is small as compared with r, thickness t can be approximated to the following formulas (E).

t**h 2/2r ..... (E)

If this is substituted for the (C) formula, the following formulas (F) will be obtained.

I(h) =I0, exp (- alpha-h 2/2r) ..... (F)

Following formulas (G) Since it is the ratio of the incident-light intensity I0 and the transmitted light intensity I, obtain permeability tau (h).

tau(h) =I(h)/I0=exp (- alpha-h 2/2r) ..... (G)

The above-mentioned formula (G) shows Gaussian distribution. When a plano-concave lens like drawing 10 is actually manufactured, since approximation by the binominal expression is performed in the above-mentioned formula (E), it does not become perfect Gaussian distribution but becomes the abbreviation Gaussian distribution from which it separated slightly from Gaussian distribution. That is, if the lens of the shape of a common concave like drawing 10 is created by the medium of an absorption coefficient alpha, abbreviation Gaussian distribution and a bird clapper understand permeability tau (h).

[0047] In drawing 6 , when permeability [of lens system L] tau (h) is abbreviation Gaussian distribution, the intensity distribution of out-of-focus image P" of the point light source P formed in Field S as mentioned above also turn into abbreviation Gaussian distribution similar to the permeability distribution.

[0048] By the way, it is known that the Fourier transform of Gaussian distribution does not have a negative value. Therefore, the response function which carried out the Fourier transform of the **** intensity distribution of out-of-focus image P" which is Gaussian distribution will have only a positive value.

[0049] Since the above-mentioned plano-concave lens has the permeability of abbreviation Gaussian distribution, in the lens system containing this plano-concave lens, its range of the spatial frequency which the response function of an out-of-focus image becomes most [the portion which takes a positive value], and spurious resolution generates is very small. Moreover, a response function can also obtain a natural out-of-focus image from monotonous reduction and a bird clapper.

[0050] As mentioned above, the lens which can acquire the effect of apodization can be manufactured by using ND glass. However, as shown also in the (G) formula, since permeability tau (h) is the function of the radius of curvature of the concave surface of a common concave-like lens, in order to obtain a desired permeability distribution, the value of radius of curvature will be restricted. This will restrict the flexibility on the design of optical system greatly, and is not desirable.

[0051] then, the 1- with the 5th operation gestalt, it is considering as the apodization filter by joining a concave surface and a convex using the plano-convex lens which has the concave surface of the above-mentioned plano-concave lens, and the convex with the same radius of curvature The material of such a plano-convex lens has a plano-concave lens, a refractive index, and the same Abbe number, and it is desirable that it is made from the glass with which only absorption coefficients merely differ. If the refractive index of a plano-concave lens and a plano-convex lens and the Abbe number are the same, the flux of light cannot be refracted by both plane of composition, and an apodization filter can be dealt with as a monotonous filter which gives only a permeability distribution.

[0052] The example which created the apodization filter is shown in the following tables. Moreover, the cross section of the apodization filter of an example is shown in drawing 11 . Among drawing 11 , an apodization filter comes to join a plano-concave lens 1 and a plano-convex lens 2, and an effective radius is 15.5mm. Furthermore, the graph of the design data of permeability of the apodization filter of drawing 12] tau (h) is shown.

[0053]

[Table 1]

《アポダイゼイションフィルター》

	【曲率半径】	【軸上面間隔】	【屈折率】	【アッベ数】	【吸収係数】
R1	∞				
		T1 0.35	N1 1.507	ν1 59.0	α 0.55
R2	20.5				
		T2 9.28	N2 1.507	ν2 59.0	---
R3	∞				

[0054] In addition, an apodization filter can be obtained also by carrying out the vacuum evaporationo of the absorber, or exposing so that sensitive material may be applied to a transparent glass plate and it may become predetermined concentration so that it may have a predetermined distribution on the transparent glass plate other than the above-mentioned composition. The apodization filter created by these methods has the merit that thickness of a filter can be made thin. However, since the film pressure of an absorber and sensitive material changes with incidence quantities according to a permeability distribution, the apodization filter created by these methods has the fault that the phase change of the flux of light occurs. Moreover, the flux of

light also generates the problem which are scattered about with an absorber and sensitive material, or is reflected.
[0055] [The conditions which a taking-lens system should satisfy], next the conditions which the taking-lens system concerning this invention should satisfy are explained.
0.1<phi f/phi <2.0 ..... (1)
however, phif: -- the refractive power of the 1st group, and the refractive power of phi:whole system -- it comes out
[0056] conditional expression (1) -- the order from a body side -- the 1st group and the 2nd group -- since -- they are the conditions which are the taking-lens system equipped with the apodization filter arranged near drawing and this drawing at the 1st group of the above, and the 1st group should satisfy in the taking-lens system which performs floating which changes the interval of the 1st group and the 2nd group and moves the whole system to a body side It becomes [rectifying the spherical aberration of the whole system] insufficient and is not desirable if the lower limit of conditional expression (1) is exceeded. On the contrary, it becomes [rectifying the spherical aberration of the whole system] superfluous and is not desirable if the upper limit of conditional expression (1) is exceeded.
[0057]
- 0.3<Phi B/phi <5.0 ..... (2)
however, phib: -- the refractive power of the 2nd group -- it comes out
[0058] Conditional expression (2) is the conditions the 2nd group should be satisfied [with the bottom of the conditions with which the 1st group is satisfied of the aforementioned conditional expression (1)] of conditions. It becomes [rectifying comatic aberration] insufficient and is not desirable, while it will become superfluous rectifying the spherical aberration of the whole system, if the lower limit of conditional expression (2) is exceeded. On the contrary, it becomes [rectifying comatic aberration] superfluous and is not desirable, while it will become insufficient rectifying spherical aberration, if the upper limit of conditional expression (2) is exceeded.
[0059]
1.01<If/Ib<3.00 ..... (3)
however, If: -- the movement magnitude in the case of focusing from an infinite distance focus state to the contiguity photography distance focus state of the 1st group, and Ib: -- the movement magnitude in the case of focusing from an infinite distance focus state to the contiguity photography distance focus state of the 2nd group -- it comes out
[0060] Conditional expression (3) is the conditions which should be satisfied [with an amendment sake] of way nature comatic aberration outside the whole system under the conditions with which are satisfied of the aforementioned conditional expression (1) and (2). If the lower limit of conditional expression (3) is exceeded, in the whole system, it becomes [rectifying the method nature comatic aberration of outside] insufficient and is not desirable. On the contrary, if the upper limit of conditional expression (3) is exceeded, the amendment effect of the method nature comatic aberration of outside becomes strong too much, the balance to other aberration amendments collapses, other aberration is worsened, and it is not desirable. Moreover, if the upper limit of conditional expression (3) is exceeded, while a lens overall length will become large too much, in order to secure the amount of ambient lights, a lens outer diameter must be enlarged and it is not desirable.
[0061]
0.5<phi1/phi< 1.5 ..... (4)
however, phi1: -- the refractive power of the 1st group -- it comes out
[0062] Conditional expression (4) sequentially from a body side The 1st group, the 2nd group, and the 3rd group, It is the taking-lens system equipped with the apodization filter arranged near drawing and this drawing in the shell at either the 1st group of the above, or the 2nd group of the above. Focusing from an infinite distance focus state to a contiguity photography distance focus state is faced. In the taking-lens system which performs floating which moves the whole system to a body side, they are the conditions which the 1st group should satisfy, changing the interval of the 1st group of the above, and the 2nd group of the above, and the interval of the 2nd group of the above, and the 3rd group of the above, respectively. Since the overall length of a lens system will become long while it becomes superfluous rectifying the spherical aberration of the whole system if the lower limit of conditional expression (4) is exceeded, it is not desirable. On the contrary, it becomes [rectifying the spherical aberration of the whole system] insufficient and is not desirable if the upper limit of conditional expression (4) is exceeded.
[0063]
- 2.0<Phi2/Phi< 1.5 ..... (5)
however, phi2: -- the refractive power of the 2nd group -- it comes out
[0064] Conditional expression (5) is the conditions the 2nd group should be satisfied [with the bottom of the conditions with which the 1st group is satisfied of the aforementioned conditional expression (4)] of conditions. It becomes [rectifying comatic aberration] insufficient and is not desirable if the lower limit of conditional expression (5) is exceeded. On the contrary, since the amount of floating becomes large and the whole system is enlarged while it will become superfluous rectifying the comatic aberration of the whole system, if the upper limit of conditional expression (5) is exceeded, it is not desirable.
[0065]
- 0.5<Phi3/Phi< 3.0 ..... (6)
however, phi3: -- the refractive power of the 3rd group -- it comes out
[0066] Conditional expression (6) is the conditions which should be satisfied [with an amendment sake] of the spherical aberration and comatic aberration of the whole system under the conditions with which are satisfied of the aforementioned conditional expression (4) and (5). It becomes [rectifying comatic aberration] insufficient and is not desirable, while it will

become superfluous rectifying spherical aberration, if the lower limit of conditional expression (6) is exceeded. On the contrary, it becomes [rectifying comatic aberration] superfluous and is not desirable, while it will become insufficient rectifying the spherical aberration of the whole system, if the upper limit of conditional expression (6) is exceeded. Moreover, if the upper limit of conditional expression (6) is exceeded, the amount of floating will also increase, and the whole system will be enlarged.
[0067]
1.01<I1/I3<2.50 ..... (7)
1.01<I2/I3<2.50 ..... (8)
however, I1: -- the movement magnitude in the case of focusing from an infinite distance focus state to the contiguity photography distance focus state of the 1st group, and I2: -- the movement magnitude in the case of focusing from an infinite distance focus state to the contiguity photography distance focus state of the 2nd group, and I3: -- the movement magnitude in the case of focusing from an infinite distance focus state to the contiguity photography distance focus state of the 3rd group -- it comes out
[0068] Conditional expression (7) and (8) are the conditions which should be satisfied [with an amendment sake] of way nature comatic aberration outside the whole system under the conditions with which are satisfied of the aforementioned conditional expression (4), (5), and (6). If conditional expression (7) and the lower limit of (8) are exceeded, in the whole system, it becomes [rectifying the method nature comatic aberration of outside] insufficient and is not desirable. On the contrary, if conditional expression (7) and the upper limit of (8) are exceeded, the amendment effect of the method nature comatic aberration of outside becomes strong too much, the balance to other aberration amendments collapses, other aberration is worsened, and it is not desirable. Moreover, if conditional expression (7) and the upper limit of (8) are exceeded, a lens overall length becomes large too much and is not desirable.
[0069]
0.5<(ra-rb)/(ra+rb) <15.0 ..... (9)
however, the radius of curvature of the image side of a biconcave lens in case an image side consists of a biconcave lens, a positive lens, and a positive lens from the radius of curvature of the body side of a biconcave lens in case an image side consists of a biconcave lens, a positive lens, and a positive lens from ra:apodization filter, and rb:apodization filter -- it comes out
[0070] Conditional expression (9) is shape factor of a biconcave lens in case an image side consists of a biconcave lens, a positive lens, and a positive lens from an apodization filter in the taking-lens system which has an apodization filter. If the lower limit of conditional expression (9) is exceeded, it will become superfluous rectifying the spherical aberration and the curvature of field of the whole system, and the amendment will become difficult. On the contrary, if a upper limit is exceeded, strong lower part nature comatic aberration will occur, and rectifying will become difficult.
[0071] By the way, in order to exert the effect of apodization even on an axial outdoor daylight bunch, it is required to lessen KERARE of the axial outdoor daylight bunch of the whole system as much as possible. In order to make it not generate KERARE of an axial outdoor daylight bunch, as for an apodization filter, arranging near the drawing is desirable. When the apodization filter has been detached and arranged from drawing, as for the axial outdoor daylight bunch with a large field angle, a part will reach KERARE ****** with an apodization filter. According to the effect of apodization, the side in which the out-of-focus image of KERARE ****** does not have a part KERARE **** by the apodization filter serves a KERARE ** side as usual, although it is good. Consequently, an unsymmetrical out-of-focus image will be formed and it becomes very unnatural.
[0072] Moreover, in the taking-lens system which has an apodization filter, image quantity y' and when it considers as the maximum image quantity Ymax, in y'=0.5Ymax, it is required to satisfy 80% or more of image surface illuminances. In y'=0.5Ymax, if an image surface illuminance is less than 80%, an unnatural out-of-focus image will be generated the effect of the effective apodization which carries out the flux of light pair outside a shaft is not not only acquired, but, and it is not desirable.
[0073]
[Example] Hereafter, construction data, an aberration view, etc. are mentioned and the taking-lens system concerning this invention is shown still more concretely. in addition, the 1- which mentioned above the next examples 1-5 -- the 5th operation gestalt -- respectively -- corresponding -- **** -- the 1- the lens plot plan showing the 5th operation gestalt is **********(ing) lens composition of the corresponding examples 1-5
[0074] In each example, ri (i= 1, 2, 3 ...) is counted from a body side. The radius of curvature of the i-th field, di (i= 1, 2, 3 ...) is counted from a body side, shows the i-th axial upper surface interval, counts nickel (i= 1, 2, 3 ...) and nui (i= 1, 2, 3 ...) from a body side, and shows the refractive index and the Abbe number to d line of the i-th lens or a filter.
[0075]
[Table 2]

《実施例 1》
f=135.0 FNO=2.8

[曲率半径]		[軸上面間隔]		[屈折率]		[アッベ数]	
r1	54.492	d1	10.001	N1	1.72000	ν1	50.31
r2	591.895	d2	0.250				
r3	49.709	d3	10.501	N2	1.71700	ν2	47.86
r4	78.066	d4	3.300				
r5	676.833	d5	2.801	N3	1.75520	ν3	27.51
r6	35.170	d6	6.000				
r7	∞(絞り)	d7	2.000				
r8	∞	d8	8.000	N4	1.51823	ν4	58.96
r9	∞	d9	7.000				
r10	-390.274	d10	2.840	N5	1.86756	ν5	41.98
r11	60.015	d11	6.005				
r12	84.000	d12	6.010	N6	1.71700	ν6	47.86
r13	-906.832	d13	1.000				
r14	154.940	d14	5.006	N7	1.66608	ν7	47.95
r15	-174.856						

[0076]
[Table 3]

《実施例 2》
f=135.0 FNO=2.8

[曲率半径]		[軸上面間隔]		[屈折率]		[アッベ数]	
r1	74.529	d1	8.105	N1	1.74400	ν1	44.93
r2	501.457	d2	0.400				
r3	58.729	d3	16.878	N2	1.62280	ν2	56.88
r4	-342.594	d4	3.608	N3	1.61659	ν3	36.61
r5	68.127	d5	4.912				
r6	751.659	d6	3.228	N4	1.74000	ν4	28.24
r7	41.653	d7	5.400				
r8	∞(絞り)	d8	1.350				
r9	∞	d9	8.000	N5	1.51823	ν5	58.96
r10	∞	d10	8.740				
r11	-39.421	d11	8.890	N6	1.71736	ν6	29.50
r12	-44.979	d12	0.270				
r13	129.471	d13	6.005	N7	1.60311	ν7	60.74
r14	-197.719	d14	0.300				
r15	1000.000	d15	4.000	N8	1.66608	ν8	47.95
r16	-400.000						

[0077]
[Table 4]

《実施例 3》
f=135.0 FNO=2.8

[曲率半径]		[軸上面間隔]		[屈折率]		[アッベ数]	
r1	54.303	d1	13.018	N1	1.72000	ν1	52.14
r2	1157.220	d2	0.250				
r3	46.959	d3	8.022	N2	1.69350	ν2	51.83
r4	102.841	d4	3.000				
r5	560.397	d5	4.025	N3	1.75520	ν3	27.51
r6	35.170	d6	9.000				
r7	∞(絞り)	d7	2.000				
r8	∞	d8	8.000	N4	1.51823	ν4	58.96
r9	∞	d9	7.000				
r10	-113.347	d10	2.839	N5	1.74400	ν5	44.93
r11	47.730	d11	6.004				
r12	73.206	d12	6.009	N6	1.71700	ν6	47.86
r13	-195.000	d13	1.000				
r14	154.940	d14	5.006	N7	1.66608	ν7	47.95
r15	-174.856						

[0078]
[Table 5]
《実施例 4》
f=135.0 FNO=2.8

[曲率半径]		[軸上面間隔]		[屈折率]		[アッベ数]	
r1	57.222	d1	13.001	N1	1.72000	ν1	52.14
r2	1463.443	d2	0.250				
r3	49.023	d3	8.000	N2	1.71300	ν2	53.93
r4	110.073	d4	2.300				
r5	343.160	d5	4.000	N3	1.75690	ν3	29.69
r6	35.170	d6	11.000				
r7	∞	d7	8.000	N4	1.51823	ν4	58.96
r8	∞	d8	1.000				
r9	∞(絞り)	d9	7.000				
r10	-57.450	d10	2.829	N5	1.66755	ν5	41.98
r11	80.714	d11	5.000				
r12	280.558	d12	5.000	N6	1.67003	ν6	47.15
r13	-88.734	d13	0.230				
r14	81.658	d14	6.000	N7	1.72900	ν7	53.48
r15	-195.000	d15	1.000				
r16	-1589.850	d16	2.002	N8	1.72000	ν8	52.14
r17	79.868	d17	2.000				
r18	165.821	d18	3.502	N9	1.66998	ν9	39.23
r19	111.926	d19	2.000				
r20	142.970	d20	5.501	N10	1.68892	ν10	45.01
r21	-150.321						

[0079]
[Table 6]

《実施例 5》
f=100.0 FNO=2.8

[曲率半径]	[軸上面間隔]	[屈折率]	[アッベ数]
r1 48.604	d1 12.000	N1 1.72000	ν1 50.31
r2 749.732	d2 0.185		
r3 37.876	d3 7.000	N2 1.72000	ν2 54.71
r4 92.244	d4 2.083		
r5 250.110	d5 2.983	N3 1.75690	ν3 29.69
r6 26.052	d6 8.148		
r7 ∞	d7 8.000	N4 1.51823	ν4 58.96
r8 ∞	d8 1.000		
r9 ∞(絞り)	d9 5.000		
r10 -48.249	d10 2.095	N5 1.86755	ν5 41.98
r11 76.499	d11 3.704		
r12 423.582	d12 4.000	N6 1.67003	ν6 47.15
r13 -74.053	d13 0.170		
r14 60.477	d14 5.000	N7 1.72900	ν7 53.48
r15 -144.444	d15 0.741		
r16 -1178.162	d16 1.484	N8 1.72000	ν8 52.14
r17 59.160	d17 1.481		
r18 122.825	d18 2.594	N9 1.66998	ν9 39.23
r19 82.907	d19 1.481		
r20 105.903	d20 5.000	N10 1.71700	ν10 47.86
r21 -93.071			

[0080] Moreover, the change of the axial upper surface interval each lens between groups in the case of focusing from an infinite distance focus state to a contiguity photography distance focus state and the movement magnitude by the side of a body in each example are shown in the following tables as floating data. In addition, the maximum contiguity scale factors beta are beta=1/2 in beta=1/4, and examples 3-5 in the examples 1 and 2.
[0081]
[Table 7]
フローティングデータ

	群間隔変化 (∞～近接)	物体側移動量		
		第1群	第2群	第3群
実施例1	d13: 1.000～9.358	41.79	33.43	------
実施例2	d14: 0.300～11.760	38.48	26.75	------
実施例3	d6: 9.000～6.960 d13: 1.000～9.180	40.90	42.94	34.76
実施例4	d6: 11.000～8.130 d13: 1.000～21.100	57.44	60.31	40.21
実施例5	d15: 0.741～15.194	48.18	33.72	------

[0082] Furthermore, the refractive power of the lens group of each example is shown in the following tables.
[0083]
[Table 8]

レンズ群屈折力

	φ1	φ2	φ3
実施例 1	0.00277	0.00806	-------
実施例 2	0.00597	0.00233	-------
実施例 3	0.00747	-0.00676	0.00806
実施例 4	0.00700	0.00830	-0.00180
実施例 5	0.01084	-0.00012	-------

[0084] Drawing 13 - drawing 17 are the aberration views corresponding to the aforementioned examples 1-5, respectively. The above figure shows an infinite distance focus state among each drawing, the following figure shows the aberration in a contiguity photography distance focus state, and each aberration view corresponds to spherical aberration, astigmatism, and distortion sequentially from the left. In a spherical-aberration view, spherical aberration and a dotted line SC express sine condition, respectively. [as opposed to d line in a solid line d] Moreover, in the astigmatic view, the dotted line DM and the solid line DS express the astigmatism in a meridional side and a sagittal side, respectively.
[0085] Moreover, examples 1, 2, and 5 satisfy conditional-expression (1) - (3), and examples 3 and 4 satisfy conditional-expression (4) - (8), respectively. Furthermore, conditional expression (9) has satisfied examples 1 and 3. The value of each conditional expression is shown in the following tables.
[0086]
[Table 9]

各実施例の条件式の値

	実施例 1	実施例 2	実施例 3	実施例 4	実施例 5
条件式 (1)	0.37	0.80	---	---	1.46
条件式 (2)	1.09	0.31	---	---	-0.02
条件式 (3)	1.25	2.56	---	---	1.43
条件式 (4)	---	---	1.01	0.95	---
条件式 (5)	---	---	-0.91	0.85	---
条件式 (6)	---	---	1.09	-0.24	---
条件式 (7)	---	---	1.18	1.43	---
条件式 (8)	---	---	1.24	1.50	---
条件式 (9)	1.36	---	2.45	---	---

[0087]
[Effect of the Invention] As explained above, according to the taking-lens system concerning this invention, the latus range of an infinite distance focus state to a contiguity photography distance focus state can be covered, and the practical taking-lens system by which the out-of-focus image was improved can be realized.
[0088] When the taking-lens system which follows, for example, starts this invention is applied as a taking lens of a camera, a photograph with a beautiful out-of-focus image can be offered.

[Translation done.]